what you might call hands, by means of which it made its way rapidly over the coral reef. When placed on the sky-light of the steamer, the fish stood up on its four legs, a sight to behold! It was small, and something like a lizard, but with the body of a fish!" It is to be hoped that a full and scientific description of this latest marvel of deep-sea dredging may soon be published, as the specimen appears to have been brought back to Melbourne. Mr. White, too, of the same Expedition, tells strange tales about the rats. "The little island," he said, "upon which we pitched our tent was overun with them, and what was most extraordinary, they were of every colour from black to yellow, and some tortoise shell!"

AMONG other collections made by Prof. Marsh during his explorations in 1871 were additional specimens of the pterodactyl, first obtained in 1870. Portions of five individuals were procured; and among them nearly all the bones of the right wing of one, which exhibited the pterodactyl structure in its perfection. The teeth found with the other remains were somewhat similar to those of the pterodactyls of the Cretaceous of England, being smooth, compressed, elliptical, and somewhat curved. A second species, still larger than the other, was obtained in the Upper Cretaceous, near the Smoky River, in Western Kansas. The expanse between the tips of the fully-extended wings was probably as much as twenty-two feet. In all, Prof. Marsh has determined the existence of three species from the same region, which he characterises in the April number of the *American Journal of Science.* In the same journal Prof. Marsh refers to the interesting discovery that the body of mosasauroid reptiles was probably covered with plates, as in some crocodiles, the head itself being smooth. This fact has been ascertained in regard to specimens of all the American genera, so that probably all the species possessed it.

THE second Report of the Geological Survey of Indiana, made during the year 1870, under the direction of Mr. E. T. Cox, State geologist, has just made its appearance, and, like its predecessor, appear to be a work of much scientific value. In addition to the series of reports upon the geology of the counties, it embraces a paper upon the Western coal measures and Indiana coal, and a paper upon palæozoic zoology, and closes with an extended manual of the botany of Jefferson County, Indiana, prepared by Prof. A. H. Young, of Hanover College. In this the total number of indigenous species is given at 537, those introduced numbering 72.

ANOTHER book of excellent typographical execution has just appeared from the public printing-office of the United States, in the form of the astronomical and meteorological observations made at the United States Naval Observatory during the year 1869, under the direction of the superintendent, Admiral B. F. Sands. This volume, forming a stately quarto of over 900 pages, is prefaced by a detailed account of the transit circle, the meridian transit instrument, the mural circle, and the equatorial of the observatory, and followed by a statement of observations made with these instruments. The volume also contains the meteorological observations for 1869, the positions of the sun, moon, and planets during that year, as made with different instruments, &c. The report of the total eclipse of December 22, 1870, which has already appeared as a separate memoir, is included in this volume, as also an appendix embracing the zones of stars observed with the mural circle in the years 1846, 1847, 1848, and 1849. The observatory is now in excellent condition, and includes in its working force some of the best astronomers and mathematicians of the country; among them Profs. Newcomb, Hall, Harkness, Eastman, &c. The completion of the gigantic telescope now in process of construction by Alvan Clark will constitute an important addition to the means of research, and will doubtless be turned to good advantage.

ON THE SOUND MADE BY THE DEATH'S HEAD MOTH, "ACHERONTIA ATROPOS"

THE singular cry produced by the Death's Head Moth has for a long time been known to naturalists, and the question of the exact method of its production has given rise to much discussion. To judge, however, from the latest writings on the subject, the matter is considered even now as being far from definitely elucidated. In the autumn, about six years ago, I was lucky enough to rear over a hundred imagos of *Acherontia atropos* from pupæ obtained from potato diggers in the neighbourhood of Bristol. I made then some observations on the production of the sound in question, but I did not consider them as sufficiently perfect for publication. I got no more specimens until last autumn, when I obtained a single imago from ten pupæ, but on this I made an experiment which I believe to be crucial in the matter. Absence from England, however, on the Government Eclipse Expedition, has prevented my giving an account of my experiment until now.

On looking into the literature of the subject, in which task I have been kindly assisted by Prof. Westwood and Prof. Rolleston, I found it in its extent far exceeding my expectations. The number of theories which have been invented to account for this apparently simple phenomenon is astonishing; and as the history of the question is really very interesting, I shall commence by giving as complete an account of what has been written on the subject as I have been able to obtain by reference to works in the Radcliffe, Bodleian, and Linnean Society's libraries, and in that of Prof. Westwood.

The earliest writer on the subject was Reaumur (Mémoire pour servir à une Histoire des Insectes, 1734-1742, vol. i. pl. 14), who suggests that the noise is most probably due to the same cause as in certain scarabei, which produce a sound by the rubbing together of certain of their scaly parts. Later on (*loc. cit.* vol. ii. p. 24) Reaumur states that he has made further experiments, and concludes that the sound is produced by the rubbing of the proboscis against the palps. He held the palps aside from contact with the trunk, and the sound ceased. But he is of opinion that air may have something to do with the matter, and makes his statement with caution. There is a membrane stretched at the base of the trunk, he says, which may have something to do with it; and finally, "Je ne me lasserai point de répéter que nous devons nous attendre, que dans les plus petits sujets il restera toujours quelque chose que nous ignorons." It would have been well if some of the many subsequent writers or the subject had profited by this sage remark. The next autho is Roesel (Insecten Belustigung: Nürnberg, 1755, § 16), whose observations, according to Wagner, were very superficial; and who considers the sound due to friction between the opposed surfaces of the abdomen and thorax. Next comes Rossi (Istoria della Farfalla a testa di Morto, Opuscoli di Milano, Ann. 1782) who is the first to arrive at a correct result, and says the sound is due to expiration of air through the trunk. Schröten (Der Naturförscher, xxi. Stück: Halle, 1785) gives as a cause the rubbing of the trunk against the head. Engramelle, as quoted by Passerini, without special reference, makes the sound come from the part of the insect called the spallette.

There is now a considerable chronological interval, and then Godart and Dupronchel (Hist. Nat. des Lépidoptères de France. par M. Godart. tom. iii. pp. 18 et 19) report a letter from M. Lorey, retired army surgeon-major, who describes a peculiar pair of organs, situate on the sides of the abdomen, surrounded by long hairs, which, when the animal squeaks, may be seen to elevate themselves, and form a conical cavity leading to an opening. He considers the sound to be produced by the passage of the air through this opening. It will be seen further on that this peculiar pair of organs was subsequently described as a discovery by two writers ignorant of the literature of the subject.

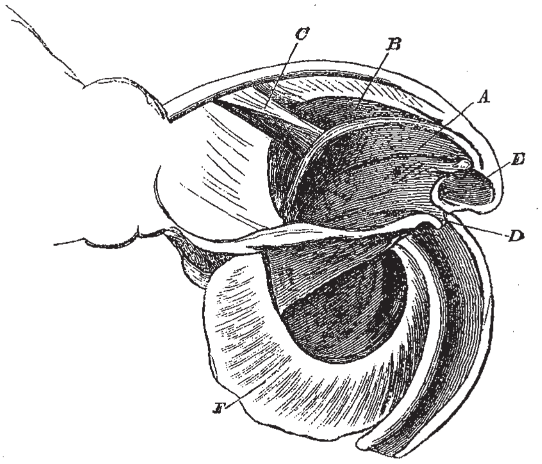
Next comes Passerini, who went to the very root of the matter, and explained the whole thing correctly and clearly in a monograph entitled, "Osservazioni sopra la Sphinx Atropos o Farfalla a testa di Morto," del Dottore Carlo Passerini: Pisa, 1828. He commenced his experiments in 1824. He first disposes of Lorey's theory by showing that his peculiar organs exist only in the male insect, whereas both male and female Death's Heads produce the sound; and further, that the same organs exists in the males of other moths, as *Macroglossa stellatarum*, and *Sphinx convolvuli*, which produce no sound. Next he records this startling experiment:—A moth may be divided in two through the middle of the thorax, and the anterior extremities will still continue to speak. This experiment disproves absolutely all theories which connect the sound with the abdomen in any way, by friction or otherwise. He next removed successively from a moth the palps, the trunk, and the spallette, and the insect nevertheless continued to squeak. He then cut away carefully with a sharp knife the horny top of the head of another specimen, and observed certain muscles rising and falling in rapid motion when the animal squeaked, but remaining quiescent as soon as the sound ceased. As long as these muscles were left intact the insect might be mutilated in almost any manner without the sound being stopped. If these muscles were divided longitudinally, or transversely, the power to emit sound was lost. In quite a fresh specimen, he says, in examination after death, the upper part of the head is found filled with an indurated cellular structure, and beneath this are found the elevating and depressing muscles. Beneath these is an inclined shining horny surface of triangular form leading to a narrow transverse aperture corresponding with the opening of the proboscis tube. At the back of the incline is a very fine aperture, leading into the body of the *Sphinx*. He concludes that the air enters the cavity of the head by the fine aperture, and is driven out through the narrow transverse one by the action of the muscles just described, and that thus the sound is produced.

Chavannes wrote on the subject (Act. Soc. Helv. Sc. Nat. 17; Isis: Genève, 1832, pp. 93-94), but I have not been able to refer to his memoir, nor to that of Rochebrune (Act. Soc. Scient. Bordeaux, 1832, t. 5, pp. 120-122, tab. 1.) Then we have H. Burmeister (Handbuch der Entomologie, Berlin, 1832), who after citing Reaumur and Rossi says, "This much is certain, the organ of voice is seated in the head." Then Vallot (*L'Institut*, 1834, II., No. 34, p. 7), who demolishes to his own satisfaction all previous theories, and adopts that of Johet, which considers the sound to be produced by the striking of the wings in rapid movement against certain parts. Wagner (Müller's Archiv für Physiologie, III., 1836, pp. 60-62), after satisfying himself that the sound came from the head, unrolled the trunk, and found that the sound became feebler, but did not cease. When he held the two halves of the trunk apart, or cut off one or both up to the base, the sound ceased. He found just in front of the true stomach a crop very large, distended with air, and filling up the whole anterior part of the abdomen, and opening into the posterior extremity of the œsophagus. He could not find any special apparatus in the trunk, but he says that there appears to be a fine slit-like opening at the basis of this organ on its inferior surface, formed by the imperfect closure of the two halves of the trunk. This may have something to do with the matter. He could not find Passerini's cephalic cavity. The proboscis has strong, transversely-striated muscles. Duges (Traité de Physiologie comparée, par A. Duges: Montpellier, 1838, vol. ii. p. 226) ascribes the noise to the rubbing together of the opposed edges of the two halves of the proboscis.

We have theories already in abundance, and there are more yet to come; but we now come on repetitions of previous theories by persons who either had not access to, or were too lazy to consult, the writings of the original inventors of them. Dr. Alex. V. Nordman (Bull. Acad. St. Petersburg, 1838, t. 3, pp. 164-193) says the sound is seated neither in head nor proboscis, but in the abdomen; and he then proceeds to give an elaborate description of the peculiar organs already discovered by M. Lorey, and he congratulates himself not a little on his having been able, after the failure of so many previous investigators, to make this discovery, and to set the matter finally at rest. We next have observations and experiments made by MM. Duponchel and Guerin (Ann. Soc. Ent. France, 1839, t. 8, pp. 59-65). To show that Passerini was wrong, they compressed the trunk at the base sharply with forceps, and also stopped the end of the proboscis, but apparently in a very insufficient manner. The noise did not cease. They had only one individual on which to operate, and therefore could not afford to mutilate it and repeat Passerini's experiments. Their conclusion is that the noise has the nearest analogy to that emitted by Longicorn beetles, which is produced by the rubbing of the prothorax against the smooth portion of the scutellum. Goureau (Ann. Soc. Ent. France, 1840, t. 9, pp. 125-128) says, "Reaumur, Passerini, Lorey, all are wrong. There is no special organ for the sound. The sound is of a double nature. There is one shrill part of the sound which proceeds from the vibrations of the thoracic rings; in another part a grating sound is caused by the rubbing of the shoulders against the thorax." Abicot (Ann. Soc. Ent. France, ser. 2, 1843, t. 1, Bull. p. 50) says that amputation of the trunk stops the noise, therefore Goureau is wrong.

Ghiliani (Ann. Soc. Ent. Fr., ser. 2, 1844, t. 2, Bull. pp. 72, 75) comfirms Passerini. He cut off the head and the sound stopped. He held the trunk horizontally, and at various inclinations, the sound continued; he removed the palps, the sound continued; he dipped the head in oil, the sound ceased. He then amputated the trunk at its root. Three apertures were formed by the operation, one corresponding to each half of the proboscis, the other probably to the prolongation of the buccal cavity situate just above the trunk, and opened by the knife when amputating the trunk. A green liquid flowed from the third opening over the cut root of the trunk, in which liquid large bubbles were seen to be formed by the expiration accompanying each sound. On closing the apertures the sound ceased. He is unable to explain how inspiration and expiration are managed. Paris (Ann. Soc. Ent. France, ser. 2, 1846, t. 4, Bull. pp. 96, 142) thinks the noise due to a mucous fluid which the insect forces by aspiration, with the assistance of the palps up and down inside the proboscis, comparing the process to the flow and reflow of a liquid in a suction and force-pump.

J. Vander Hoeven (Tydschr. Entom. Neder Vereen, 1859, t. 2, Stück 4, pp. 117-122) says the source of the sound is certainly in the head. In an Indian species of *Acherontia* he has found tuberosities all over the basal portion of the trunk. The exterior surface is beset with stiff bristles. On rubbing this surface against the edge of a piece of paper or scalpel, a sound like that of the moth is produced. He considers the moth's cry to be due to friction of this kind.



Vertical section through the median line of the head of *A. atropos*, from a specimen preserved in absolute alcohol. *A*, dome-shaped cavity of Passerini. *B* and *C*, depressing and elevating muscles of this cavity. *D*, narrow orifice, leading from the cavity to the tube of the proboscis. *E*, palpus.

Westmaas (Tydschr. Entom. Neder Vereen, 1860, t. 3, pp. 120-124) extended the trunk on a pin, and at the same time pulled the palps aside. He still heard the sound, though it became feeble. He cut off the palps without effect on the sound. He cut off the trunk bit by bit, as it was gradually shortened the sound diminished. A fluid exudation covered the end of the trunk, and he saw bubbles of air formed in this as each sound was emitted. He confirms Passerini. He notices that the insect produces a louder sound when the trunk is coiled up. The moth when emitting a sound elevates the front of its body, and uses an evident effort. He stopped the aperture of the trunk with grease, the crying ceased; he kept one specimen half a day with the trunk aperture thus closed, it emitted no sound, but on the grease at last being removed squeaked at once. In order to test Wagner's theory, he squashed out the abdomen quite flat, so as to destroy any air cavity it might contain; the animal still squeaked. Chapronnier (Ann. Soc. Ent. Belg. *Comptes Rendus*, pp. 16, 17) says that the noise produced by the larva is due to the snapping together of the mandibles. An imago, which he bred, which had a deformed head, emitted no sound; therefore the sound organ is situate in the head.

Finally, we find some discussion of the matter in the *Entomologist*. Edward Newman (*Entomologist*, August 1865, p. 284), says, "With regard to the sound produced by the pupa and imago, A vast deal has been written, but nothing worth repeating." But he surely cannot have sufficient grounds for this sweeping demolition of previous authors, and certainly cannot have consulted this "vast deal which has been written;" for he proceeds to enunciate the very theory first put forth in the year 1755 by Rossel, and subsequently revised by Duponchel in 1839.

E. A. Johnson (*Entomologist*, Nov. 1865, p. 325, *Field* newspaper, Oct. 24, 1865) describes the organs discovered by M. Lorey before the year 1828, and subsequently by Nordman, in 1838. W. H. Taylor (*Entomologist*, Nov. 20, 1865) brings forward Passerini's objection to Lorey's theory, viz., that males only have these organs, while both sexes squeak, and that other species which produce no sound possess these organs. Thus does history repeat itself. In the same page of the same journal we have some remarks on the subject from the Rev. A. Preston, who, when sticking his pin-point into an insect in killing it, and moving the pin up and down against a muscle, heard a sound just like that of the mouth. He does not, however, from this observation draw any very definite conclusion.

It will be found that there are eleven distinct theories in all which have been put forward to account for the cry of this moth. By far the greater number attribute the phenomenon to friction of various parts, two to an expiratory effort, one to rapidly repeated percussion, and one to the intervention of a fluid.

The foregoing contains the pith of all the writings on the subject which I have been able to meet with. I have no doubt there are many others in existence, but I hardly expect that I have missed any of importance.

I am not aware whether all known species of *Acherontia* emit a sound; but a closely allied species in Ceylon is described by Sir Emerson Tennant, in his "Natural History" of that island, as doing so; and I was lately, whilst in Ceylon, informed by several residents that such was the case. This Ceylon species is probably *Sphinx Acherontia Lethe*, described by Prof. Westwood in his "Oriental Entomology," p. 87.

I now pass to my own observations on the subject. I was killing a specimen out of the large number which, as stated above, I bred about six years ago, by means of a solution of cyanide of potassium, which I was using with a pen in the ordinary manner, the animal squeaking loudly under the operation. A drop of the fluid happened to fall on the extremity of the proboscis. I noticed that at each squeak a large bubble was formed, showing a forcible expiration from the organ. I repeated this experiment constantly with water, and always with the same result. I further extended the trunk with a pin during the emission of the sound, and noticed a modification in the tone of the cry, which varied with the amount of extension. These experiments convinced me that the sound came from the proboscis, and was produced by an expiration. I at that time knew nothing of the literature of the subject, and very little of anatomy, and I unfortunately made no further observation or experiments in the matter; and it was not till last autumn that I was able to pursue the subject further on a single specimen which I was fortunate enough to rear. This specimen was a very lively one, and it squeaked freely. I placed a tight ligature on the extremity of the proboscis whilst it was in the act of emitting its cry. The noise stopped instantly. I kept this specimen two days, and handled it constantly, bullying it in all sorts of ways to try and get it to squeak, but without result. After the proboscis had been thus ligatured for two days, I amputated the lower portion of the trunk just above the ligature. The animal instantly began squeaking, and continued to do so at intervals for two days more, when I killed it in order to examine the anatomy of its head. I fancied my experiments at the time quite novel, and it was only the other day that I found that similar ones had been made by Ghiliani and Westmaas; but the method of ligaturing the proboscis, with subsequent amputation above the ligature, is, I think, more satisfactory than Westmaas's use of wax.

After these experiments, taken in confirmation of what has already been done in the matter, I think there can be no doubt that the sound is produced by expiration through the proboscis. We have now to consider—How is this expiration effected? Whence comes the air expired? and Whereabouts in the proboscis or head is the actual spot where the sound is formed? I think it will be found that Passerini's explanation is in almost every respect satisfactory. I had no time to dissect my Death's Head whilst in the fresh state last autumn, but preserved it in absolute alcohol. The accompanying drawing of a preparation made from it may therefore need slight modification on further investigation; but in the main it will be found correct. The figure represents a magnified view of a vertical section along the median line of the head. A is the large dome-shaped cavity, evidently the one described by Passerini, and which R. Wagner could not find. This cavity has a hard chitinous floor, which is prolonged forward so as to project over the proximal extremity of the proboscis (seen here in section with its end amputated), and there ends in a sharp edge, which forms, with the anterior wall of the cavity, a narrow transverse slit, leading to the proboscis tube, just as described by Passerini. Resting on the roof of the dome-shaped cavity are Passerini's muscles, B and C, with some cancellar-like tissue between them and the external wall of the head. It would obviously be easy to expose these muscles as Passerini did with great ease and very little disturbance to the insect's functions, and I cannot see any reason to doubt that they would be found in action just as he describes.

Passerini does not figure the muscles or describe them accurately. He merely calls them elevating and depressing muscles. The muscle C must obviously on contraction raise the dome-shaped cavity, whilst B must depress it. An alternate action of the two muscles would cause the cavity to act as a bellows, and inhale and expire air through that aperture which allowed it to pass and repass most freely. Passerini believed that the air entered the cavity by the œsophageal opening at its hinder part, which he describes as very narrow (*loc. cit.*, p. 6) ("Da tutto cio che ha esposto credo poter concludere che l'aria dalli'nterno della sfinge vien portata alla cavita muscolare della testa per mezzo dell' esilissima tuba"), and was expelled then by the proboscis; but that this is really the correct explanation is scarcely probable. First of all, the posterior opening into the cavity must be very small indeed. I cannot find it at all in the present specimen, and it is highly probable that it may often be aborted altogether, as is the case in most butterflies. Moreover, how should the air get into the œsophagus? Certainly not from the abdomen as supposed by Wagner, for Westmaas showed that the animal could squeak after the abdomen was squashed out flat, and Passerini himself showed that an insect would emit the sound after it had been divided in two through the middle of the thorax, an experiment which of itself is sufficient to overthrow his own view. The opening into the proboscis being by far the largest leading into the dome-shaped cavity, the air probably finds ingress as well as egress by this aperture. And if I remember rightly the bubbles formed on the end of the proboscis in my experiments always collapsed between the squeaks, showing this to be the case. I think that there can further be no doubt that the note is formed at the narrow slit-like opening, the sound being modified by passage through the proboscis tube, and by vibrations therein set up, this latter to account for modifications produced by straightening the trunk or by gradually removing it bit by bit from below (Westmaas).

I further think it probable that there is a movement of the proboscis concerned in the production of the sound. If the base of the proboscis were drawn a slight distance directly forward at each inspiration, the upper opening of that organ would be brought more immediately beneath the narrow passage communicating with the dome-shaped cavity, and the ingress of air would be rendered more free. Then if at expiration the base of the proboscis were retracted again, the aperture of egress would be very much contracted, and the formation of the sound facilitated. It would be interesting to observe whether such a motion of the proboscis takes place. I think I remember to have noticed a slight movement of the trunk during the emission of the sound.

It is most extraordinary that the seat of the sound should ever have been imagined to be anywhere but in the head. One has merely to listen to the animal to detect at once where the sound comes from. It would seem as if many writers on the subject had commenced their observations with a determination to find some other seat for the cry. The animal is a large one, and one could as easily persuade oneself that a mouse's cry proceeded from the tip of its tail as that of a Death's Head from its abdomen. Should I obtain specimens of *A. atropos* this autumn, I hope to repeat Passerini's experiments, and also make certain whether inspiration as well as expiration takes place through the proboscis; I think also that Wagner's narrow slit on the under surface of the proboscis should be experimented on.

H. N. MOSELEY